THE

AËRONAUTICAL JOURNAL.

(Founded 1897 in succession to the Annual Reports).

The Organ of the Royal Aëronautical Society.

Published Monthly at the Offices of the Society, at 7, Albemarle Street, Piccadilly, London, W.1.
Telephone: "Gerrard 7373." Telegraphic Address: "Didaskalos, Piccy, London."
Subscriptions per annum, post free, £1 10s.; single numbers, 2s. 9d.

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All communications should be addressed to the Editor.

No. 106. OCTOBER, 1919. Vol. XXIII.

Notices of the Royal Aëronautical Society.

Obituary.

We regret to record the death of Lieutenant-Colonel John Cyril Porte, R.A.F. Colonel Porte was elected an Associate Fellow of the Society in 1913 and was made a Fellow in 1918. Lieutenant-Colonel Porte was one of the foremost pioneers in the development of aircraft and made his mark with the flying-boat with which his name is connected.

The Transactions.

We have pleasure in announcing that the first number of the "Transactions" of the Society has now been issued. This is "The Calculation of Stresses in Aeroplane Wing Spars," by Arthur Berry, M.A. Copies can be obtained from these offices, price five shillings.

The Membership List.

Members are reminded that a supplement to the list of members will be issued at Christmas. As it is desired that this should be as accurate and complete as possible members are requested to forward any notifications of change of address or other particulars at once.

Educational Opportunities.

The Secretary receives frequent inquiries respecting educational opportunities in the form of scholarships and exhibitions at the various universities and engineering colleges. He would be obliged if members of the Society who may be acquainted with information of this character would advise him at an early date. A complete register of scholarships and premiums of this sort would be of great value to the student members of the Society.

Elections.

The following have been elected to the Society in the various grades:—

Fellows.—Horatio Barber, Angus R. Fulton, A. Grahame Clarke.
Associate Fellows.—F. A. Best, A. Davenport, W. R. Savage, W. H. Eccles.

Members.—H. Carrington, L. L. Wood, T. J. Arnold, G. G. H. Cooke, G. Harris, J. H. Hume, Sir John Hunter, H. F. Luck, J. J. Somerville, Major G. H. Scott, W. Stroud, Major-General J. G. Weir.

Associate Members.—J. M. Londen, A. P. Mitchell, J. Montgomerie, C. Nicol, A. C. Parkinson, W. Purves, H. A. Sams, J. D. Shotter, C. V. Wallace, T. Lamb, W. G. Johnson, J. Harvie, J. Hamilton, G. S. Greenland, H. Hargreaves, A. F. de Moleyns, H. S. Bourne, H. C. Black, A. Speedie.

Student Members.—F. G. Ball, R. N. Bell, L. J. Jones, A. El-Kirdany, E. S. Wicks, M. A. Zahra.

POSSIBILITIES OF AERIAL TRANSPORT IN PERU.

BY G. M. DYOTT.

To anyone who has made a careful study of aeronautics and its possibilities in the commercial world it is evident that South America offers unusual opportunities for development by aircraft, and of all South American countries Peru, on account of its climate, its rich natural resources, its geographical position and its peculiar topographical configuration, is almost ideal. To fully appreciate the significance of this remark it is necessary to have a very clear conception of all those factors which go to make aerial transport a commercial possibility.

The topography of the country is of peculiar interest because it is more marked and more intense than that of any other part of the great South American continent. Sandy desert vibrating with heat; mountain peaks glistening in the land of perpetual snow; deep rocky gorges and vast tropical forests are all within a few days' ride of each other. When travelling through the interior we find that distances are relatively short, but the difficulties encountered in traversing them are colossal. Range after range bars the traveller's progress as he journeys eastward from the coast, and when after weeks of incessant travelling he finally emerges on the flat ground of the Amazon and its tributaries his passage is blocked by miles of impenetrable forest through which it is impossible to proceed further. Forced to travel by river, periodic whirlpools and rapids make progress slow and dangerous. Even when these are left behind submerged logs are a continual menace to navigation; besides the river, as it winds and wriggles over the low-lying ground, covers two or three times the actual distance represented by a straight line drawn from point to point. This then is the dominant reason for regarding Peru as so amenable to aeronautical exploitation, especially when on top of all it is remembered that many of these inaccessible districts are rich in mineral and other natural resources which make it worth while bringing them in easy reach of the outside world. It is doubtful if there is any area of the same size in any part of the globe so well suited for aerial transport as this. On the coast there are an infinite number of natural landing grounds available, and even amongst the high peaks of the Andes there are frequent table lands of considerable size which could be drained and levelled at no great cost. In the region of woods also the rivers afford mile after mile of waterways upon which hydro-aeroplanes could come to rest in safety. The mountain ranges would probably be the worst obstacles to overcome, but the highest of these need not be tackled at the outset and much valuable work could be immediately accomplished on the coast. At a later period routes could be established over the lower passes of the Andes, such as Huarmaca, and then in the light of additional experience the highest ranges could be surmounted with ease.

In the general scramble of recent years to produce war machines of startling performance the question of cost has been almost entirely lost sight of. The fact that an aeroplane could accomplish things which no other known mechanism could do was sufficient to justify its existence. In the business world an entirely different state of affairs exists and cost is the final verdict upon which the art must sink or swim.

A comparison of costs between canal barge, railway, motor lorry and aeroplane shows that the cost per ton mile varies from a small fraction of a penny in the first case to as much as eighteen or nineteen shillings in the last. In the face of this very alarming figure it is by no means easy to define just what position is occupied by aircraft in the world of transportation. If I were called upon to do so I would say that it was not a load carrier, but essentially an expensive piece of

machinery for saving time. Now throughout all Latin American countries, with the exception of a few large cities, time is of little or no value. Therefore there is no need of introducing costly machinery to save it. Under such circumstances one might just as well forget about aerial transport in this part of the world until the native inhabitants wake up to a proper appreciation of time and its value. There can be no doubt but what the opportunities for saving time are extraordinarily great, but this feature can only be appreciated by those who have travelled through the interior, especially Peru, where a hundred mile journey is more difficult than one of five hundred miles in Brazil or the Argentine. A typical example may serve to illustrate the point. Bauga-Chica, a small but important town on the Utcumamba river, is barely 140 miles from the Pacific coast. Yet to travel there by present means of locomotion takes two whole weeks of hard riding on mule back. A moderately fast aeroplane could accomplish the same journey under two hours.

Briefly, we find Peru and its adjacent republics highly susceptible to development by aircraft, but the most important element of all which would justify such costly means of locomotion is almost entirely lacking. Fortunately, Peruvians on the coast are already beginning to fall in line with modern ideas, and Europeans, to whom time is a very valuable asset, are acquiring large business interests all over the country and their wants will have to be considered.

A word of warning might be given to those intending to start enterprises in this part of the world. It would be a fatal error to count on the support of local inhabitants in any shape or form. Of course there are a few exceptions to this in and about large centres of population, but strange as it may seem the very people to be benefited might be openly hostile to such an innovation. Quite recently the Columbian Government was approached by an American firm with a view to establishing aerial service between Bogota and the coast. After some discussion the authorities replied that should the venture prove a failure it probably meant fatal accidents in which Columbians would be killed. If, on the other hand, it was successful then a lot of foreigners would be brought to the capital, both of which alternatives were undesirable. This is quite typical of the attitude of the inhabitants of many sections of South America.

It has already been pointed out that an aeroplane cannot possibly compete in the transportation of freight and merchandise with other means of locomotion under normal conditions. However, when abnormal conditions obtain an aeroplane can often come to the rescue and show a profit on the right side of the ledger. The following typical examples of abnormal conditions came under my notice in Peru and are well worth serious consideration in view of the fact that others of a similar nature can be found.

On the east side of the Maranon river near Soledad, in the department of La Libertad, are some gold mines being developed by a Russian, Sr. Tarnivisky. About 60 tons of material and machinery has been brought up from Salaverry on the coast 90 miles away at a cost averaging £100 a ton. It has taken three full years to do this and another six months will have passed before the mine and mill are in operation. A suitable aeroplane would have moved the same freight with the greatest ease within six months and shown a profit at the same rate of £100 per ton. The profit would not have been all on the side of the transportation company either, as the owners of the mine would have started production three years earlier and thus saved interest on capital for three barren years, to say nothing of profits that might have been made during that time had the mine been working. The machinery was all built in special small sections suitable for mule transport. This increased its first cost and delayed delivery. An aeroplane could have transported every piece in its normal section, thus saving further expense and delay. On a rough calculation Sr. Sota, the manager of the mine, figured out that the company could have afforded to pay £140 a ton to get the machinery on the ground within a year. It so happened that but a short distance

above the mine was a large pampa and of such proportions as to make an excellent landing ground at very little cost. Not only would the particular mines of Sr. Tarnivisky have benefited by the advent of aeroplanes, but also the villages of Soledad, Parcoy, and others which now lead a life of complete isolation, although only 90 miles from the coast. If only owners of properties in some of these inaccessible districts could once get in their preliminary plant to open up their mines and prove their value money would be forthcoming for building good trails or even railways at a later date. As it stands capital will not interest itself in undeveloped properties and the owners cannot afford to spend money on trails and wait years for their machinery, hence everything is at a standstill. To successfully handle work of this kind aeroplanes of special design would have to be employed. A slow speed multiple engine machine with fuselage of large volume would be the most suitable type.

In a general way we may say that carrying freight under abnormal conditions really means exploration and development work. As soon as an industry was well established in a certain district and contact with the outside world became easy then the railway with its cheaper rates would follow with full assurance of procuring sufficient traffic to make it pay.

To make such a scheme successful a very complete understanding would have to exist between the aerial transport company and the railway companies, because the former would not agree under normal conditions to open up a district and the minute it was beginning to pay well to have a railway come in and take all the business, leaving them to go out to do the pioneer work in opening up new fields.

The prospects of developing the inland waterways of the country with hydro-aeroplanes are decidedly good. The many tributaries of the Amazon offer natural landing areas over thousands of miles of territory which would cost nothing to prepare or maintain. Launch service on the rivers is slow, uncertain, and at some seasons difficult. A comprehensive system of hydro-aeroplanes would do wonders in bringing in wild and uninhabited regions within easy reach of civilisation. It took the writer nearly a month to go from Iquitos to the Pongo de Manseriche, a distance which a fast hydro-aeroplane could traverse inside five hours. There would be nothing very difficult about starting regular service of this kind—in fact it would be extremely easy as compared with service in the Sierra, when once a definite plan of action had been decided on. A town like Moyobamba would benefit largely, for although situated on the river Mayo, which is of ample width, it is cut off from all communications with the main river on account of a quarter of a mile of rapids below the town which is an effective barrier to all launch service. A hydro-aeroplane could fly past this trivial obstruction and thus afford a much needed outlet to the Huallaga river and thence to Iquitos. As it is, Moyobamba is completely isolated, but for a perilous trail, viz., Balzapuerto, which is enough to deter the most hardened traveller from passing that way. The journey to Chachapoyas to the westward is over a trail equally as bad and the one south to Taropota is no better.

Gold dredging has been attempted by many companies in the Santiago and Alto Maranon rivers. Each effort has met with failure after spending colossal sums on machinery and strenuous efforts in bringing the equipment up river. Failure has always resulted because adequate means of rapid communication with civilisation was never maintained. In one case a small but important part of the machinery broke; a canoe was despatched to Iquitos with the part, but all was lost in the river. After two months waiting another party set out and after eight months returned only to find the dredge overgrown with vegetation and abandoned by the few remaining men who had not died of fever. Had the company spent £3,000 on a good hydro-aeroplane they would have been within four hours of Iquitos and able to meet a situation of this kind with great promptness. After all, an expenditure of 2 per cent. on the value of the machinery would not have been an extravagant price to pay.

Equally important as the aeroplanes themselves is the provision of suitable and adequate landing grounds upon which they can alight to take on or discharge their cargo. No definite law can be laid down regulating their number although in a vague way we realise that their number over a given route would be in certain proportions to the reliability of the aeroplane and its motor. If we take any two points 100 miles apart it is evident we must have a landing ground at each end. If the aeroplanes used were absolutely reliable then there would be no need for emergency landing grounds in between. If, on the other hand, the aeroplanes used were the reverse and subject to failure any moment then a landing ground should stretch continuously from one point to the other. Between these two extremes can be chosen any arrangement most suitable for the service contemplated. In general an emergency ground every 50 miles would be reasonable, but if one could be provided every 20 miles then so much the better. Emergency grounds should be regarded as insurance against breakage. The more there are of them the better, but if the cost of preparing them is high then the extra cost might not be justified.

On the coast zone the preparation of these would be very easy as there is hardly a place which could not be turned into a perfect landing ground if necessary at very low cost. On the high puna lands also there are some fine stretches of ground that could be chosen and the chief expense would be drainage and the erection of a shed to house the machines in when they landed. At slightly lower altitudes some inter-Andean valleys have ideal grounds that could be used with very little preparation. For example, Cajamarca, Huamachuco, and the valley of the Mataro river about Huancayo. In the lower or more abrupt valleys the problem is more difficult, but even here there are a few places that could be utilised.

At Bella Vista, just above the juncture of the Maranon and the Chinchipe rivers, there is as good a landing ground as one could wish to see. Further up the valley are periodical banks of gravel occurring at bends in the river of sufficient size to land an ordinary machine on. These extend almost as far south as La Vina. At Chusgon the river bottom could be prepared by diverting the stream into one channel instead of allowing it to meander in all directions as it does now. Above the lake of Pias is a wide bar of gravel which would also be very good indeed if the river was confined to but a single channel.

The most difficult places of all to find good landing grounds would be in the very abrupt valleys or on the shoulders of some of the hills. Small sections of ground would be available in such places and the solution of the problem would probably be the employment of very slow speed machines that could alight on restricted areas such as these. Machines of this particular kind would only fly short distances and would have to be of special design. Citabamba, or the valley of Huayo, Partaz, etc., would be typical districts for this kind of flying. I remember crossing the Maranon at Balsas and when on a high ridge I looked back and saw a spot on the other side of the valley that I had passed four days previously. It was not more than fifteen minutes away by aeroplane and yet it had taken me four days of constant travel, and very hard travelling at that, to cover the distance.

On the wooded eastern slopes of the Andes lying towards Brazil, possible landing grounds would be few and far between until one arrived at the flat ground of the Amazon basin. Even here the cost of making a clearing would be very high and it could only be done in special cases. Development of this section of the country would be difficult. In the low-lying ground this would not matter as hydro-aeroplanes would be used and the rivers themselves would afford the most perfect landing facilities possible.

During the year I spent in travelling through the Andes and the upper reaches of the Amazon I found my daily notes of the wind and weather conditions a source of continual and absorbing interest. In the limits of a paper such as this it is

impossible to deal with the subject in anything like an exhaustive manner, but the general results of my observations may be of interest.

Peru can be divided into three territorial zones running more or less parallel with the coast, each one having its own peculiar and distinctive features; they are generally known as the Coast Zone, the Sierra, and the Montana. The first, as its name implies, is a belt of country adjacent to the Pacific Ocean. It varies in width from a fraction of a mile up to 10 miles and is a sandy sterile desert, void of all traces of vegetation except in those localities where artificial irrigation has been practised. It extends inland as far as the foothi"s of the mountains, at which point we encounter the Sierra, or the great rocky barrier of the Andes, with its abrupt valleys, its towering peaks, and cold, bleak, uninviting uplands. This is a region of great variety of climate, hot and cold, storm and sunshine, fertile gorges and valleys so dry and desolate that even the hardy cactus gives up life in despair. On the eastern slope of the Andes we enter the Montana or region of woods, with its heavy rainfall, humid heat, and dense virgin forests. Low-lying hills are sometimes encountered locally, but generally it is flat, stretching in one great unbroken sea of green from the Andes to the eastern border of Peru and thence across Brazil to the Atlantic seaboard.

It is to be expected that over country of such widely dissimilar nature weather of great variety should occur. What surprised me most was the close proximity of some of these local variations, but I soon became accustomed to them and would often put my observations to good account by choosing routes of travel which I learnt from experience would be the least susceptible to heavy rainfall. As a general rule I found that on passing up valleys running approximately north and south the western slope was generally much dryer, less susceptible to cloud bursts and the vegetation also was much more scanty. On the other hand, if the valley ran east and west then that side which rose to the least elevation was the one to choose.

There are only two prevailing winds encountered in Northern Peru, which although varying in intensity, appear to maintain a constant direction within certain well defined limits. All other winds appeared to me to be purely local and were the direct result of sunshine and shadow. The first and most important of these air currents comes sweeping across Brazil from the eastward laden with moisture drawn up by the action of the sun from the great Amazonian forests; on striking the most easterly ridge of the Andes the majority of the moisture is precipitated in the form of rain or snow and by the time the most westerly ridge is reached very little moisture remains behind and the current continues on its way at a height of 14,000 feet and over, finally losing itself somewhere over the blue waters of the Pacific Ocean. This wind in conjunction with the sun forms what is in reality a great hydraulic machine. Approximately 95 per cent. of the moisture which it carries after falling on the summits of the Andes finds its way by devious paths back once more into the great Amazon waterway. On keeping close observations of the direction of this wind I noticed that it might occasionally veer round to the north-east or possibly southward to the south-east, but between these limits it seemed to blow with the greatest regularity.

The second prevailing wind is found on the coast and blows from the south to the south-west. It is a cold wind and so far as I could judge a shallow one. On striking the hot sandy coast of Peru it apparently rises to about 6,000 feet but not more. At times its velocity drops to almost zero, and at other times it may reach as high as 30 miles per hour. Apparently it is steady, but does not extend to any great height as in the case of the easterly wind over the mountains.

For some reason for which I could not altogether understand clouds in the vicinity of the coast and in the mountains seemed to confine themselves to certain definite strata. The first of these, particularly noticeable in the coast zone, were found between elevations of 4,000 and 6,000 feet. At some seasons of the year,

especially in the last six months, they would assume a lower elevation extending from the earth's surface to about 4,000 feet. Higher up in the mountains another strata is encountered between 10,000 and 14,000 feet and at a still greater altitude a third layer could be observed between 19,000 and 22,000 feet. The low-lying strata in the coast zone was of peculiar interest because it would reach up to a certain altitude and then end abruptly as if held down by some invisible blanket on top. The effect was very peculiar especially when viewed from a high ridge above the cloud line, as it resembled a lot of floating seaweed with roots and tentacles stretching downwards to the earth in fantastic form. The strata observed in the mountains, however, seemed to be just as ragged on the upper surface as on the lower.

Strange to say in the coastal strata I could observe no transfer of air from the clear to the cloud strata, but on two occasions I saw hot air rising locally like boiling water, pushing the clouds out of its way in all directions and leaving an aperture that would gradually close on itself again when the disturbance had ceased. This phenomenon I think is unusual and I am inclined to believe that the lower strata is actually more dense than the upper one in spite of the chill imparted to the easterly wind in its passage over the mountains.

Many are under the impression that to cross the Andes involves the passage of but a single ridge and when once this has been surmounted it is a steady descent to the Amazon forest. This is far from the case, as only in one instance can it be done, and that is in the north where the Andes reach their minimum elevation at Huarmaca. Here one can cross at 7,000 feet, follow the river Huancabamba to Bella Vista and thence by raft down the Maranon to the region of woods. All other passages mean crossing at least two and generally four or even six ridges. Between these are found high, bleak puna, or table lands, covered with a coarse grass, or else fertile valleys 8,000 to 12,000 feet above sea level. Frequently deep, narrow valleys are encountered, such as that of the Maranon, into which the sun pours its burning rays, raising the temperature to furnace heat. The deeper valleys are the centre of local winds of a highly interesting nature, and to study them I had to resort to the observation of bird flight and cloud movement.

In 1911 and 1912, when I was flying in Mexico and Central America, I found that the conditions of the atmosphere could be judged very accurately by careful observation of the flight of the turkey-buzzards. These scavengers of the air are found all over Peru, and between them and the giant condors of the mountains I was able to gather many interesting facts. It is well known that the former of these two birds can only maintain flight in calm, still air with considerable effort, and that he depends on horizontal or vertical air currents to keep himself aloft for any length of time. About eight or nine o'clock in the morning they would leave their resting places and start to essay the air, sometimes giving it up immediately and sometimes losing so much altitude in the attempt that they would be unable to regain their perch and would have to take refuge on a lower ledge or some dried-up tree in the valley. As soon as conditions for soaring flight prevailed they would all be circling and circling till lost in the blue. Invariably they seemed to prefer the sides of the valleys, which I took as an indication that they were on the look out for food, but be this as it may, closer observation showed that the air in the centre of the valley was almost always descending and it was for that reason that they generally avoided it. Many times I noticed them glide from one side to the other and invariably this manœuvre was accompanied by a big loss in altitude. Towards four-thirty all the heat eddies had stopped and down would come the turkey-buzzards to roost for the night. Frequently if their return was postponed till a late hour their landing on tree tops was very strenuous, as unable to support themselves in the falling air they would fall like a lump of lead on an extending branch and there remain till the following morning.

The behaviour of the wind over the mountain tops was of as much interest as the heat eddies in the valleys. It must be remembered that practically all

main ridges in Peru run roughly north and south, that is to say, at right angles to the prevailing wind. The eddies set up are therefore the resultant of the east wind and the hot air rising from the valleys. Three distinct effects are noted.

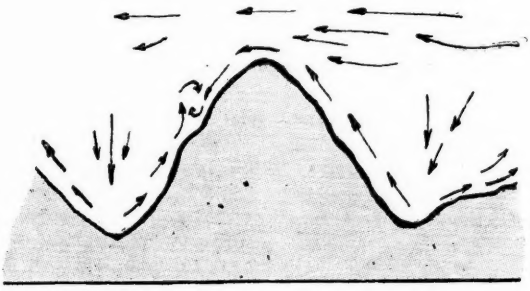

FIG. 1.

On ridges of 14,000 feet and over (see Fig. 1) the easterly wind would be so chilled that on passing the ridge it would drop down into the valley, meeting the hot air coming up on the other side. This would cause local disturbance in the atmosphere on the lee side of the summit anywhere from 200 to 1,000 feet down the slope according to the velocity of the wind and the force of the upward air currents.

Reversal of wind was not an uncommon sight to witness in cross valleys running up into ridges of this altitude. If the parent valley was narrow and subject to the sun's rays over much of its length, cold air to replace the rising warm air would be drawn from the cross valley. If the head of this valley lay to the east, then down would sweep the clouds till they arrived at a spot where the heat of the sun was enough to disperse them and kill their velocity. One day I counted eleven reversals in the space of twelve hours.

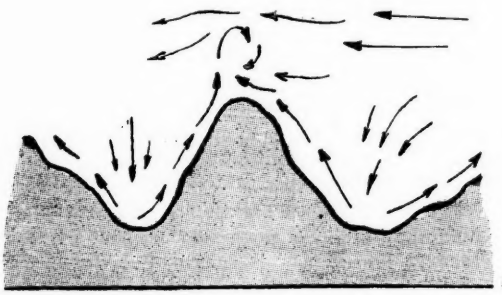

FIG. 2.

Over lower ridges having an altitude of about 12,000 feet (see Fig. 2) the heat eddies would as a rule prove the strongest, especially along the east side of the narrow Maranon valley. This was apparent because as the clouds came drifting over from the east they would be folded back on themselves, rolled up, and diverted to a higher elevation. Several times I witnessed collisions between some newly formed cloud as it travelled up a short cross valley and a low straggling one carried before the east wind. The two would meet in a silent crash,

sending up a column of whiteness that was marvellous to behold. Reversals of wind in the vicinity of these ridges was not so noticeable as in the higher ones, as the conditions most suitable for the phenomena were a combination of a short narrow valley running out of a deep hot one up to a high ridge.

On the most easterly chain of the Andes, which is heavily wooded and rises to 5,000 or 6,000 feet, a continuous reversal of wind was frequently noted during the entire day (see Fig. 3). Undoubtedly this was due to the enormous suction caused

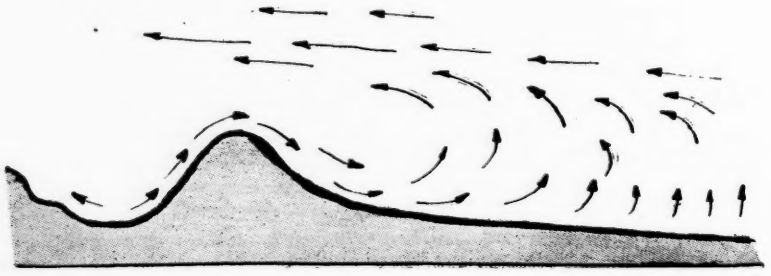

FIG. 3.

by hot air rising from the Amazon woods drawing in the cool air over the mountain tops to replace it. At night this wind would die down, but during the day would attain considerable velocity. Its effect was noticeable some 10 miles to the eastward of the range mentioned.

During all my wanderings in the mountains I never once encountered a wind blowing across a valley unless it was the prevailing easterly wind over some high puna land. In all cases local winds blew either up or down the valleys, and it was extremely interesting on some occasions where three valleys united together to observe clouds floating up or down them, sometimes in diametrically opposite directions. Yet another point that interested me was that not only did clouds follow ridges, but they always chose the highest ones for preference. A mass of clouds for instance arriving at the head of a valley would as likely as not be split in half, each half following its own side of the valley. If one side happened to be considerably higher than the other, then the clouds would all veer off to that side, sometimes leaving the lower one perfectly clear.

Contrary to general opinion I would not consider the passage of the high ridges to be very difficult. On the other hand, crossing some of these Andean valleys, I feel sure, would be risky with under-powered machines, and after 4 p.m. would really be dangerous.

In closing I would like to make a few remarks in regard to the river Amazon, as I suppose that there is no one who having had experience with seaplanes has not thought at some time or another about flying up this mammoth river and its many tributaries. Personally I would prefer to do the first 2,147 miles as far as Iquitos, the inland port of Peru, in one of the comfortable ocean-going steamers belonging to the Booth Line. This part of the journey can be divided into three sections—Salinas, where a pilot is taken on, to Para 110 miles; Para to Manaos 865 miles, and thence to Iquitos 1,172 miles. Up to this point the river is so colossal that there is not much pleasure in traversing it even in a 3,000-ton steamer. Its overall width at Iquitos is roughly two miles, the main channel being 850 metres, then an island, and then a more shallow channel of 1,700 metres width. High water marks occur in the months of March, April and May and low water July, August, September. It so happens that the northern tributaries flowing

down from Ecuador are in flood at a different time of the year from the southern tributaries, but as the seasons are not diametrically out of phase with each other there is a pronounced flood period in the river during the months mentioned.

From Iquitos to the celebrated Pongo de Manseriche there are a few tiny settlements and a small military post of Baranca. The hydro-aeroplane could alight anywhere along this part without the slightest trouble, but as there are so few habitations, sometimes 100 miles apart, and these only inhabited by half-caste Indians, there would not be much opportunity of trading. From the Pongo to Bella Vista, a distance of approximately 150 miles, landings on the river could only be made at special points, as there are many gorges and rapids and the water runs with considerable velocity.

In all of this section of the country the idea of providing landing grounds by cutting down the virgin forest is not as easy as is generally supposed. Even if this were done it would need very determined effort to keep the ground clear, as the rapidity with which vegetation grows is enormous.

Beyond Bella Vista the main river is too swift for hydro-aeroplane work, but should one have in mind to reach the Pacific Coast it is only a 140 mile journey, and there is but a single low pass of 7,000 feet to be surmounted.

There is no doubt that if, for strategic reasons, rapid aerial transport between Iquitos and the Pacific Coast was essential, then this route would be far the most practical to open up, as that one via the river Pachitea is considerably longer and over a particularly high section of the Andes. The greatest difficulty of aerial navigation through the Amazon and its tributaries would be that the population along its banks is so small as to be negligible except in the Ucayali river. Furthermore, the produce of the woods is bulky and awkward to handle. Rubber might offer inducements, but palm fibre, vegetable ivory, timber, etc., are out of consideration for aerial transport. The question of fuel would also be very serious, as at the present time ordinary petrol in Iquitos costs 7s. a gallon, and by the time it had been spread over numerous river depôts it would be higher still.

There would be as great opportunities for saving time in the regions of woods as there is in the mountainous districts. In the mountains time is lost by going continuously up and down hill, whereas in the river it is lost to the same extent by continually twisting to the right and left. The town of Yurimaguas on the Huallaga river is 150 miles away from Iquitos in a direct line, but by canoe or launch the actual distance covered is 450 miles.

People often think of the Amazon as a glorified edition of the Thames, but in reality the only resemblance is that there is water in both. In a previous paragraph I spoke of the value of time as being the all important factor in the field of commercial aeronautics. If this is applicable in the mountainous districts then it is doubly so in the rivers as here life is very primitive. The unit of time is six months, that is to say, the wet or the less wet season, each of which lasts half a year; the unit of distance is a river bend which varies anywhere between 100 yards up to many miles. All of the inhabitants are poor and the majority underfed, sickly and barely realising that they are alive. Even lower down the river where there are some prosperous planters, to rush them through the air in a few hours to their destination would be to rob them of two weeks of keen enjoyment spent on a river launch, so at the moment one can only look on aerial transport in the Amazon as an adjunct to European enterprises and nothing else.

THE LARGE AEROPLANE AND ITS LIMITATIONS.

BY A. RYAN, M.SC., A.F.R.AË.S.

The question of whether it is possible to construct very large aeroplanes equal or superior in efficiency to the smaller aeroplanes already in existence is a subject that must be occupying the minds of people connected with aeronautics.

The subject has been considered by various aeronautical engineers and scientists in the pages of the ROYAL AËRONAUTICAL JOURNAL and elsewhere.

A few of the statements of conclusions arrived at are quoted from the AËRONAUTICAL JOURNAL of 1917 in an appendix.

In England there is no doubt that the late Colonel Cody was the pioneer of the large aeroplane, as although his plane would be considered to be of moderate dimensions to-day, yet it was large in relation to its contemporaries.

The Russian Sikorsky aeroplane appears to be the next attempt of note towards the development of the large aeroplane.

Following the late Alexander Sée, Major A. R. Low developed a theory published in several papers ("Engineering," 1913, "Junior Institution of Engineers," 1913, and AËRONAUTICAL JOURNAL, 1917, etc.), in which the limit of size on the basis of the 1912 army trials, with a useful lift of 1/5 of the total, is 12½ tons at sea-level, subject to the reservation that this limit would increase with every improvement in design and materials of construction.

The first aeroplane of more than 10 tons gross weight was built in 1915-16 under the technical supervision of Mr. Harris Booth, late of the Admiralty Air Department, and although this particular machine was not satisfactory, yet the work of Mr. Booth and his staff proved invaluable in the development of the modern aeroplane of 5 tons weight and upwards. The late Colonel Porte was responsible for the parallel development of the large flying boat in England and America, whilst Caproni and others have developed large aeroplanes on the Continent.

Mr. Handley Page is no doubt the chief exponent of the large aeroplane in England and gave his views on the subject in his paper on "The Case for the Large Aeroplane" before the Royal Aëronautical Society, 1917. As a result of his experiences with large bombing machines of 14 tons weight and upwards, he is now of the opinion that the limit of serviceable size has been reached with present materials.

As a further contribution on the subject it is now proposed to consider the matter in a simple manner and put forward a practical case that will show that there are limits to the size that an aeroplane may be made and still retain aerodynamic efficiency, but whether these limits will come within the desirable commercial requirements remains to be seen.

Those who give us their opinion that there are limits to the size of efficient aeroplanes base their views on the known facts:—

A. The weights of structures similarly loaded and of equivalent strengths vary as the cube of the linear dimensions.

B. The gross lift of an aeroplane varies as the square of the linear dimensions of the planes.

Therefore, if all other items, such as resistance, vary as the square of the dimensions, or are proportional to the total lift of the aeroplane, which comes to the same thing, then it is true that the weight of the structure increases at a

more rapid rate than the lift or area of the planes until at some point there is no margin between the two, and therefore the machine could not rise from the earth under its own power. Long before this point is reached the aeroplane would be considered inefficient as a weight carrying machine.

As a starting point in these considerations we may take a 4 ton aeroplane to the following particulars:—

1.	Gross lift or weight	4 tons = W.	
2.	Area of planes	960 sq. ft.	
3.	Power	500 h.p.	
4.	Speed (maximum)	90 m.p.h.	
5.	Power plant weight	1.3 tons = 32.5%	
6.	Net weight of plane structure	1.0 ton = 25.0%	
7.	Weight of landing gear	.2 tons = 5.0%	
8.	Weight of covering	.1 ton = 2.5%	
9.	Weight of crew (two men)	.14 tons = 3.5%	} 35%
10.	Useful lift	1.26 tons = 31.5%	}
11.	Resistance at 90 m.p.h.	= .16 W = .64 tons	
12.	H.P. used at 90 m.p.h. with 75% over-all efficiency	= 460 h.p.	

We will now consider the effect of increase in size under the following conditions:—

(*a*) All sizes to have the same speed, viz., 90 m.p.h.
(*b*) The load per sq. ft. of surface the same for all sizes, viz., 9.32 lbs. per sq. ft.
(*c*) Density of atmosphere constant.

CASE 1.—If now we assume the simple conditions, as quoted in (A) and (B) above, and use the same percentage of weight for all items except 6 and 7, we find that the net weight of aeroplane increases so rapidly with size that at about 17.6 tons there would be no useful lift and that at a much lower figure the aeroplane would be very inefficient as a load carrying machine.

The question arises as to how this serious disadvantage is to be overcome and the efficiency retained in large planes as in smaller planes, and if so, to what extent can this be done.

CASE 2.—Firstly, consider the question of resistance. Since the resistance of an aeroplane at this speed is about .16 W, we see that 1 lb. of resistance is equivalent to 6.25 lbs. of weight. (N.B.—8 or 9 lbs. at gliding speed.)

If, therefore, we can save in the matter of resistance in regard to size such that the total resistance of the aeroplane varies at a lower rate than the square of the dimensions, then we can express this in terms of weight and reduce the increase in weight of structure accordingly. (N.B.—Actually the saving is in power required and consequently less power plant weight is necessary and other things are reduced in proportion.)

Now the total resistance of an aeroplane is made up as shown in a separate paper, where we obtain that the resistance may be expressed as follows:—

$$R = .08\,W + .127\,W^{2/3}$$

We can translate this into saving in proportionate increase in weight by subtracting this from what the resistance would be if it varied as the dimensions squared, and multiply by 6.25.

$$6.25\,\{\,.16\,W - (.08\,W + .127\,W^{2/3})\,\}$$

We may now consider other points to see if a like saving may be effected elsewhere.

Power Plant Weight.

As larger aeroplanes necessitate larger engines, greater scope is given to construction of engines of larger B.H.P., larger petrol and oil tanks. This leads to economising in weight per h.p. by allowing of more cylinders per engine. Also if we use larger tanks we have a better vol./area ratio. Fittings, piping, etc., are in many cases the same weight and in others vary as diameter × length only.

The case may be put the same way as by Major Low, viz. :—If k = power plant weight/horse-power is plotted against h.p. and the total weight of power plant for successful types, the limiting curve shows a decrease of weight per h.p. which is fairly rapid for small powers, but above 100 h.p., say, the curve becomes nearly a horizontal straight line.

This means that although some advantage is gained at first by increase of size, yet ultimately there is no gain in this respect, and if we commence with a 500 h.p. 4 ton machine we cannot expect any improvement unless there is improvement in design, except that due to reduced resistance as shown in the previous paragraph.

Weight of Covering of Planes in Proportion to Size.

As the load per square foot will remain practically constant, then the strength and weight of the fabric per unit area need only remain the same provided more ribs are used and are spaced the same distance apart instead of being made larger in dimensions, and therefore this item increases as the square of the dimensions and no improvement can be expected on this account over Case 1.

Weight of Crew.

The following figures appear reasonable for the number of crew required :—

Number of crew.	Total weight of machine.
2 men	4 tons
4 men	16 tons
5 men	25 tons
8 men	64 tons
10 men	100 tons

These figures vary as $W^{1/2}$ and taking the weight of a man as .07 tons :—

Weight of crew = .07 $W^{1/2}$ which represents a saving of (.07 W — .07 $W^{1/2}$) tons in comparison with Case 1.

Landing Gear.

As the length of the struts, which are the chief structural components, is generally about the same whatever the size, it follows that, as the speed is the same, the strength and weight of these vary practically in proportion to W. Also the landing wheels may be made in proportion to the weight of the machine and therefore vary as W, the relative saving in this item being, therefore :—

$$.2\left\{\left(\frac{W}{4}\right)^{3/2} - \frac{W}{4}\right\} \text{ tons.}$$

Total Net Weight of Aeroplane and Crew. Case 2.

The total weight of an aeroplane under the above conditions may therefore be divided up and expressed as follows :—

Structural portion of wings, tail and other parts having aerodynamic functions :—

Proportional to the cube of the dimensions and therefore $= C_1 W^{3/2}$.

Where C_1 is a constant and W = gross flying weight of aeroplane.

(NOTE.—This does not allow of fining details with increase of size or alteration in arrangement of planes to economise weight.)

Power Plant Weight.

Proportional to the resistance and therefore

$$= C_2 (.08\ W + .127\ W^{2/3}).$$

Landing Gear Weight.

Proportional to weight of machine $= C_3 W$.

Weight of Covering.

Proportional to area of wings, etc., $= C_4 W = .025\ W$.

Total Net Weight then Equals

$$\{ C_1 W^{3/2} + C_2 (.08\ W + .127\ W^{2/3}) + C_3 W + .07 \times .5\ W + .025 W \}$$

Evaluation of constants using the practical figures for a 4-ton machine:—

$$C_1 4^{3/2} = 1 C_1 = \frac{1}{4^{3/2}} = .125$$

$$C_2 = \frac{1.3}{.08 \times 4 . 127 \times 4^{2/3}} = 2.03$$

$$C_3 = \frac{.2}{4} = .05$$

Using these values we then have that the net weight of an aeroplane and its crew of any size designed for 90 miles per hour and similar in other respects to the 4-ton machine, may be stated thus:—

$$\begin{aligned} W_P &= \{ .125\ W^{3/2} + 2.03\ (.08\ W + .127\ W^{2/3}) + .05\ W + .07\ W^{1/2} + .025\ W \} \\ &= \{ .125\ W^{3/2} + .1624\ W + .258\ W^{2/3} + .05\ W + .07\ W^{1/2} + .025\ W \} \\ &= \{ .125\ W^{3/2} + .2374\ W + .258\ W^{2/3} + .07\ W^{1/2} \} \end{aligned}$$

From this it will be seen that the useful lift is zero at 27 tons, as against 17.6 tons in Case 1.

We will now examine the conditions further to consider if any further economies may be effected as the size is increased, either by reduction of power plant weight or weight of structure.

Saving in Power Plant Weight Due to Decreased Resistance owing to the Increased Length of the Chord of the Planes and other Parts where Resistance is Largely Due to Skin Friction.

CASE 3.—If we use the same result for this, as found by Zahm and others, we may state that the resistance varies as $A^{.93}$ where A is the total area exposed to skin frictional resistance.

According to the views of Lanchester and others the greater part of the total resistance of planes and streamlined bodies is due to skin friction. To allow for this skin friction effect we can with tolerable accuracy modify the first portion of

the resistance formula which practically represents the aerodynamic resistance by substituting in place of .08 W a value $AW^{.93}$ and determine A such that the two values are equal when $W = 4$ tons.

Thus,

$$.08\ W = AW^{.93} \text{ and } A = .088.$$

The resistance formula then becomes

$$R = (.088\ W^{.93} + .127\ W^{2/3})$$

Saving in Weight of Structure by Fining Details and Utilising Built Up or Hollow Members in Place of Solid Ones.

This may be stated briefly as designing in such a manner as to have all the material of the structure stressed to the same factor of safety. When this is accomplished the limit of lightness for any material is reached.

We will now consider whether it is possible to obtain a suitable expression to represent this saving in proportionate weight with increase in size.

It is evident that the economy in proportionate weight will at first be fairly rapid and that ultimately it will become equal to zero and extreme difficulty would be experienced in reduction of weight long before the limit is reached.

We may from examination of present designs assume that about half the structural material is fully stressed and the other half, on an average, one quarter stressed.

Then we may state that one quarter of the material is used for practical reasons as apart from opposing the forces on the structure.

One way of correcting the limiting figures for this would be to subtract this quarter from the original weights of structural parts and deduce all other figures from these reduced weights. These figures if plotted would form a limiting curve of weights under these conditions.

The total weight of an aeroplane under these modified conditions may then be stated as follows:—

$$W_P = .09375\ W^{3/2} + 2.03\ (.088\ W^{.93} + .127\ W^{2/3}) + .0375\ W + .07\ W^{1/2} + .025\ W$$
$$= .09375\ W^{3/2} + .179\ W^{.93} + .258\ W^{2/3} + .07\ W^{1/2} + .0625\ W.$$

Here the point of zero useful lift is moved to 63 tons in comparison with 27 tons for Case 2, and 17.6 tons in Case 1.

Case 4.—It is possible that in future improved materials of better strength, weight ratio and better methods of construction will be available, and a further economy may be effected. We will consider what effect a further reduction in weight of structure would have, assuming that by such means the equivalent weight of the 4-ton plane and landing gear would be reduced a further 25% from the original weight.

The total weight of the plane would then be:—

$$W_P = .0625\ W^{3/2} + .179\ W^{.93} + .258\ W^{2/3} + .07\ W^{1/2} + .05\ W.$$

The effect of this is to move the point of zero lift upwards to 158 tons, although the useful lift begins to show a value less than 32% at 45 tons.

Case 5.—Further, we will examine what effect we may expect in connection with the making of large efficient aeroplanes when by improvements in design and materials that may occur in the future the total power plant weight may be

reduced to 3 lbs. per h.p. in addition to incorporating all other improvements indicated in the previous cases.

The equation for the total weight then becomes:—

$$W_P = .0625\ W^{3/2} + .0922\ W^{.93} + .133\ W^{2/3} + .07\ W^{1/2} + .05\ W.$$

The effect of this is not so great as that of the previous case, but it appears that the efficiency of larger aeroplanes would be considerably improved, the limit of zero useful lift in this case being 189 tons and the point at which the percentage useful lift is the same as for the original 4-ton plane is 70 tons.

CASE 6.—Finally we will examine the effect of reducing the resistance by improved aerodynamic efficiency to such an extent as to realise Lanchester's prophecy that the limit of resistance would become .1 W instead of the .16 W used in these calculations.

The first effect of this would be to reduce the weight of power plant required and afterwards there would be secondary effects where reduced stresses would be brought about and a consequent saving in weight of structure could be effected. However, we will neglect the latter as we may safely consider that the weights of structure, etc., could hardly be reduced below the figures given for Case 5.

The total weight formula would then become:—

$$W_P = .0625\ W^{3/2} + .0577\ W^{.93} + .083\ W^{2/3} + .07\ W^{1/2} + .05W,$$

and the curve for this case shows zero lift at 210 tons and a useful lift of 32% at 85 tons.

It will be interesting to tabulate side by side the particulars of the hypothetical 4-ton plane as represented in Cases 4, 5, and 6 with the original particulars we commenced with in order to visualise the relative degree of improvement required to realise the possible efficient development of very large aeroplanes having a total lift of say 100 tons.

	Original. Tons.	Case 4. Tons.	Case 5. Tons.	Case 6. Tons.
Power plant weight	1.3	1.3	.67	.42
Net weight of plane structure	1.0	.5	.50	.5
Weight of landing gear ...	.2	.1	.10	.1
Weight of covering	.1	.1	.10	.10
Weight of crew	.14	.14	.14	.14
Useful lift	1.26	1.86	2.49	2.74
Power	500 h.p.	500 h.p.	500 h.p.	313 h.p.
Speed	90 m.p.h.	90 m.p.h.	90 m.p.h.	90 m.p.h.

It will be noted that in Case 5 the useful lift plus weight of crew would be 66% and in Case 6 72% of the total.

In conclusion, the author would state that whilst he is aware that the methods adopted may be subject to criticism both as regards the absolute accuracy of the figures assumed and the method of calculation, yet it is hoped that useful information may be obtained and a clear view of the value of really large aeroplanes can be obtained and their possibilities examined by a development of the matter set forth.

APPENDIX.

(*Extracts from* AËRONAUTICAL JOURNAL.)

Mr. LEONARD BAIRSTOW, F.R.S., challenged Mr. Page's conclusions and stated that there *are limitations* and there will come a time when the size of the machine increases in which you will not be able to increase the useful load; the

load will increase more rapidly than the weight. If it were possible to increase the size at less than the cube of the dimensions, then we could certainly do better with big machines.

Major A. R. Low: With regard to the large America shown by Wing-Commander Malone, the writer has to remind his critics that he has carefully hedged against being tied down to any specified number of tons as a final limit.

Actually the present day calculated figure derived from practice seems to have increased from 12½ tons to 15 tons at sea-level, or from 5 to 6 tons at 10,000 feet with full tanks for 6 hours duration at sea-level, the factor of safety being adequate (say about five) and the load, excluding fuel, being one-fifth of the total weight.

The large America may actually exceed these figures, I think it does not, but can only do so by means of better materials and construction.

If it really defies the physical principles underlying the curves of limiting sizes, then so much the worse for the pilots.

Much of what Mr. Handley Page has said about economising weight on large machines by fining details is true, but it is repeated with emphasis that this detail saving is small compared with the rapid increase of the cube of the dimensions which controls the increase of the weight.

Captain W. S. Farren, R.A.F.: From a purely design standpoint, the case as between a small and a large aeroplane seems to me to depend upon the answer to the following question:—

Given a large load (say a ton) divisible into any number of parts, will it be more economical to carry it on a number of small aeroplanes or on one large one? (If the load is not so divisible it is evident that the smallest aeroplane which can be considered is one capable of carrying a ton, *i.e.*, a large aeroplane, and for this purpose the case of the large aeroplane is proved.) It is my experience that this question must be answered in favour of the small aeroplane.

This, of course, supposes that in both cases the same top speed, rate of climb, and duration of flight are required. The reason on which I base this opinion is that I find, in agreement with Mr. Lanchester and Captain Green, that the weight of the structure of the aeroplane per square foot increases as the size of the aeroplane increases, at any rate up to the size of aeroplane of which I have any experience.

It is possible that the future improvements in construction may make it necessary to modify this opinion. The only gain which the large aeroplane presents, is the saving in weight of crew. Apart from this saving, I think it is fairly well established that the useful load of two small aeroplanes is greater than that of one large aeroplane of the same gross weight as the two combined, always supposing the same top speed, rate of climb and duration of flight.

Dr. W. F. Durand (on the problem of size): One of the most interesting of the problems presented to the aeronautic engineer is that of the limiting size and the carrying capacity of aeroplanes. Is there such a limit? If so, what is it? Why is it? And how may it be removed or extended?

In dealing with this problem we come, of necessity, into contact with the laws of similitude of geometrically similar structures. It is well known that under simple modes of loading, geometrically similar structures of wing and fuselage will have similar factors of safety under equal unit loads. But for such structures, if strictly similar geometrically, the weights themselves will increase as the cubes of the similar dimensions, while the areas of wing or supporting surface will only increase as the square, and hence the ratio of weight to area will continuously increase as the linear dimension.

Under these circumstances, it is readily shown that, in accordance with the relation of the factors involved, there will be, for any given speed, some size for

which the lifting capacity over and above the structure will become less and less with increase in size of the structure. This would mean that, at such a point, the supporting force developed at the speed in question would be just enough to lift the structure itself from the ground, but with no reserve for additional load.

This is, of course, a definite law derived from well-known principles of geometry and calculus, and if it were the whole story it would indeed tend to raise an insuperable bar before continued expansion in size. If such were the case it would mean in effect that increase in lifting capacity could only be reached by the following measures:—

1. Reducing to a minimum the relation of weight of structure to area. That is, general improvement in the programme of design and reduction of weight of structure in relation to supporting surface.

2. Reducing to a minimum the resistance of the plane at a given speed, and likewise the relation of weight to horse-power.

3. Raising to a maximum the relation of lifting force to area, consistent however with the decrease of the total propulsive resistance of the plane.

PROCEEDINGS.

SEVENTEENTH MEETING 54th SESSION.

The Seventeenth Meeting of the Session was held in the Theatre of the Royal Society of Arts, London, on Wednesday, May 28th, 1919, Major-General R. M. Ruck, President of the Society, occupying the chair.

The CHAIRMAN announced that on the afternoon of Thursday, June 5, at half past four, a Paper would be read before the Society by Brigadier-General Lord Montagu on "Aviation as it affects India," and that Major-General the Right Hon. J. E. B. Seely would preside.

The Chairman then said, in introducing Squadron-Commander G. M. Dyott, they would have the advantage of his personal experience of flying in South America, which would be interesting to many members of that Society, for several reasons. In the first place, his Lecture was concerned with a new development and utility of flying, and, next, the special circumstances of the case would probably require some alteration in the usual design of aeroplanes. It appeared from the Lecture that the chief want would be weight-carrying machines, without any great necessity for such speed as had generally been attained by aeroplanes. It was also very instructive, as showing the difficulties of alighting, both on the mountain sides and on those big rivers which ran through South America. The landing difficulty was a very great one, and anything that could be done to improve alighting and getting off would be of very great advantage. The Lecturer mentioned some very interesting meteorological observations on the Upper Andes, which were new to him (the Chairman) and he expected were new to most of those present. He would now ask Squadron-Commander Dyott to read his Lecture.

Squadron-Commander G. M. DYOTT then delivered his Lecture.

The CHAIRMAN said it was usual to have a discussion, but it was very late. If anyone wished specially to make any remarks they would be glad to hear them.

General R. BROOKE-POPHAM said when he came there to listen to a lecture he always thought it more interesting than the last. This one was no exception to the rule. There had been an extraordinary amount of food for thought in this Lecture, and he suggested to the Aeronautical Society that it would be of great value to aviation if they could get a regular series of lectures like that, showing the possibilities and difficulties aviation had to contend with in various countries of the world. The only proviso should be that they should try and get lectures of the type of the one they had listened to that evening. He was afraid it would not be very easy. He thought the Andes sounded an ideal spot in many ways for commercial aviation. It was an extraordinarily difficult country, apparently, for railways, and the produce one could get there was ideal stuff to move about by air, being of small bulk and weight, but extremely valuable—tungsten and gold. He thought there might be enormous possibilities for an aeroplane service there to reach tungsten and gold mines which could not be got at by any other means, by railway or anything else, and it would be of extraordinary use in developing the country. The benefit of such a lecture, given by someone well acquainted with aviation, was that it showed the particular difficulties and the type of aeroplane one had to design to work in that part of the world. In the Andes it seemed one would want a machine to alight both on water and on land. That was a thing that was being developed very much at present. Apparently, one had to fly at enormous heights, and that meant one had to design an engine particularly for that work, that was, one having very high compression. If one could get a series of

lectures like the one they had heard that evening it would be a very valuable way of getting information, both as to the possibilities of aviation and the particular type and size of machines to which designers would have to turn their minds to develop aviation in all parts of the world.

Lieutenant-Colonel I. B. DAVSON said he rose with some reluctance and considerable diffidence in that discussion, but he was a little disappointed to find that the able Lecturer in the course of his remarks had not included in his programme any consideration of the aviation possibilities of British Guiana, which occupied quite a large slice of South America, and happened to be British. It consisted of about 100,000 square miles, and its vast areas were covered with a very large number of products some of which had been barely more than touched, owing to the difficulty of internal transport and communication. There were no railways in the interior, but there were broad rivers, perhaps a little more genial than the Amazon, and certainly comparatively immune from some of Squadron-Commander Dyott's fishy friends, which must be rather objectionable. Above those rivers flying boats could skim along and reach places in an hour which at present took a white man two days to reach, whether he was winning gold or anything else. It was the only British land in South America, and he thought it deserved a place under the Lecturer's somewhat comprehensive title. He ventured to hope that perhaps next time they heard him he would have added one more part to his original experience of South America.

Dr. A. P. THURSTON congratulated the Lecturer on his interesting and educational Lecture. It was particularly interesting to those who knew the country well. He (Dr. Thurston) had made two expeditions into that part of the world. He was on one when war was declared, and he gave it up when he came over to volunteer. He could only confirm everything Commander Dyott had said. On his expeditions they let up pilot balloons right across the Atlantic and up the Amazon and the Rio Negro, measuring the air currents, the height of clouds and so on. He hoped some day, when they had time, they would gather together the scientific records of those expeditions and publish them. With regard to the wind that blew over the whole of the Amazon basin, this was mostly from the north-east, and sometimes shifted to the south-east, but seldom anywhere else. It was more or less continuous, and the whole of the Amazonian basin was swept clear of mosquitos, and therefore the Amazon was fairly healthy, but the tributaries were at right angles to the prevailing wind, and were deadly unhealthy. In the rainy season the Amazon rose 50 or 60 feet, and the banks were so low that the river went over them a hundred or two hundred miles on either side of the river. The clouds were at, say, 3,000 to 4,000 feet. He endorsed everything that had been said about the inhabitants. They never did anything to-day that they could put off till to-morrow, or, preferably, a year hence. It was the land of manaña (to-morrow). It was better to go to Barbados and get negroes and carry them up the Amazon, or go to Portugal and bring them from there. He remembered having a learned and scientific discussion with a quite educated gentleman, pointing out how it would be easy to make his village free from yellow fever, because it was carried by the stigomiya, a small mosquito, which could only fly 40 yards. His argument was "yellow fever does not kill us; it only kills Europeans, and they need not come here, so why trouble?" The possibilities of landing places over the immense Amazonian forest were practically nil. There were two places, the racecourses in Para and the racecourses in Manaos. Anywhere else the land could only be cleared at great expense, and vegetation was so rapid that in a year the cleared field would be a tropical forest. They came to the conclusion that the vast area of South America could be most readily and easily covered by means of hydroplanes. The Amazon was always full of great floating logs, which could always be detected by the line of birds on them. There were also large masses of floating weeds, but one need not get mixed up with

them. But wherever one went one could land well. At Serpa the river was a little more than a mile wide and 600 feet deep and the average speed of the current was 9 knots. That was the narrowest part. Right away to far beyond Iquitos and on all the tributaries one could easily land anywhere. There was one point that had not been brought out. Special aeroplanes were wanted for that district. The climate was so extremely trying, so moist and hot that there was no glue or fabric he knew of that could stand it. It was extraordinary what damage the insects could do in a single night. In certain parts one could leave an aeroplane and find very little of it left in the morning. He had found ants 1½in. long, but they were not the worst.

Dr. Thurston then showed a number of slides, illustrating the sending up of balloons for testing the velocities of the atmosphere, the Amazon, showing some of the floating islands, the vegetation of the district, a rubber gatherer's hut and other houses, a town at the exit of the narrows coming from Para into the Amazon and the German colony in the centre of the Amazon.

Dr. Thurston said he was certain the Germans were up to something. Right in the middle of the Amazon they had a properly organised colony, with sentries, flagstaffs, gunboats and everything, and as one passed it one had to salute the German flag. It was interesting when the river flooded the forest to take one's canoe and paddle under the trees. The river having risen 50 or 60 feet, some of the palms were under water, and others were level with the canoe, so that one could stretch out a hand and pick the fruit. There were also wonderful humming birds and marvellous butterflies and flowers.

Lieutenant-Colonel CAVE-BROWNE-CAVE said there was one point that came home to him acutely. That was the difficulty of using aeroplanes or flying-boats under many circumstances which simply did not occur in the case of airships. He thought the conditions were so exceptional in this case that the advantages in favour of the airship were very great indeed. Very great speed was not required, and it was necessary to carry considerable weight for considerable distances. That was essentially an airship job. If it were proved in practice that an aerial service was required the airship would give the necessary weight-carrying capacity.

The PRESIDENT said he was sure they all appreciated very much the beautiful slides and pictures the Lecturer had shown. He doubted whether it would have been possible to have brought home the real position to their minds by any other means. He agreed with General Brooke-Popham that a series of lectures somewhat on the same plan, with pictures and slides, would be of a high educational order in dealing with the problems of civil aerial transport in the future. As regarded the future of civil aerial transport in South America, the general impression left in his mind by the Lecture was that there were not only difficulties of landing, but also a lack of any commercial enterprise which would make it worth while. But there were exceptional cases where it appeared that aerial transport might be extremely useful. They had heard nothing on that occasion about the postal communication side. He had always viewed aerial communication between those great cities on the east and west of South America as important. He presumed the airship would be the chief means of communication, but it was not easy to see how trade could develop rapidly in those districts at present. If there were a line of communication there from Europe he took it trade would develop. It was a very rich country and he supposed it would probably develop by the combined use of airships, hydroplanes and aeroplanes. He could not see that there was any very near future for it, except as a main line of communication between Europe and the big cities in South America. He moved a hearty vote of thanks to Commander Dyott.

The LECTURER said he had refrained from throwing too many roses and bouquets about as to the future, because he thought they were inclined to over-

estimate the capabilities of the aeroplane, and to think that because it can carry a ton of bombs it could carry a ton of bricks. He thought it possible that between some of the large centres on the Pacific Coast and other parts of South America a need for aerial postal communication would come about, but the foreign element there did not want to be hurried. It shook its head and said there was no particular reason why it should hurry. But when the Governments of the countries there considered employing aeroplanes for strategic reasons there would be good grounds for employing them on that one basis. The Government controlled three types of country, the montani, the coast and the woods. When the Government wanted a few thousand pounds to build a bank, or such like, at Lima it took them from the people of Iquitos. The Iquitos would like to break away from Peru and join Brazil. They had to send officials to watch the Government's interests, and then send more officials to see that the others were doing their job, and aeroplanes would facilitate that kind of work. If countries like Peru and Bolivia failed to keep a sharp eye on their territory the breaking up of their countries into small ones would go on. The spending of a few thousands of pounds now might save them losing millions of pounds' worth of territory later on.

ABRIDGMENTS OF RECENT PATENT SPECIFICATIONS (AERONAUTICS).

123,629. G. H. Thomas, 27, Buckingham Gate, London, and G. S. Wilkinson, 5, Sunny Gardens, Hendon, Middlesex. March 26, 1918.

Internal Combustion Engines; Crank Chambers.—An aeroplane engine is supported as an overhanging structure from the extremity of the fuselage. A flange on the engine body is bolted to a plate which is itself secured by bolts to a frame constituting the front end of the fuselage. The plate may be stiffened by ribs and flanges. Tie rods are pivoted to the engine body and bolts. From each point where the frame and plate are bolted, stay-rods diverge to the opposite corners of the corresponding panel of the fuselage.

123,633. Sir W. G. Armstrong, Whitworth and Co. and R. G. Lock, Elswick Works, Newcastle-upon-Tyne. March 27, 1918.

Aerostats.—A cover for a hole in the fabric of the outer cover of an airship is formed with opposite slits and is attached by stitching and press-buttons to the outside of the fabric at the part rearward of the slits and by straps at the part in front of the slits, the latter part being inside the fabric.

123,669. A. W. Mathys, 52, Chancery Lane, London. (General Inventions and Patent Bank; 776, Keisergracht, Amsterdam.) June 4, 1918.

Tanks.—Relates to supply and discharge fittings for tanks for petrol and other inflammable liquids. In order to fill the tank the petrol supply and discharge pipe, the lower end of which is fitted with a liquid seal, is connected with the petrol supply pipe of a supply tank, whilst a pipe is connected to the upper part of the latter so that the mixture of petrol vapour and inert gas may pass through the liquid seal to the supply tank. During discharge from the tank a pipe is connected to a source of inert gas under pressure, which is admitted through a spring-loaded non-return valve.

123,691. A. T. Allen, 112, Regent Street, London. August 15, 1918.

Aerial Warfare.—Consists in a bullet-proof shield for protecting gunners and others on aircraft, which can be moved round the cockpit and adjusted at any desired angle upon either side or end thereof. The drawings show the shield mounted to slide on a ring adjustable on a universal joint within the cockpit. The ring can be inclined longitudinally or laterally about a joint and the shield can be fixed in any position on the ring by a screw. The shield may also be tilted in a plane at right-angles to that of the ring if desired. When out of use, the shield may be moved round to a position behind the gunner's seat which has a bracket for supporting the ring in its lowest position.

123,748. Stabilimenti "Biak" Ing. A. Pouchain, 12, Corso, Stupinigi, Turin, Italy. February 18, 1919. Convention date, February 21, 1918.

Aeroplane Axles.—An aeroplane axle is formed of vertically elongated I-section with the flanges bent or curved, and at the ends the two flange surfaces form arcs of a single circle to take the wheels as described in Specification 123,074. The section of the axle may be varied along its length.

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